CLAIMS

What is claimed is:

1. A quadrature phase modulation receiver for a spread spectrum communications system, the receiver comprising:

   (a) a mixer for mixing a received spread spectrum signal with a heterodyne signal to convert the frequency of the received signal to an intermediate frequency;

   (b) a regulated oscillators module coupled to the mixer for producing the heterodyne signal and an intermediate frequency signal;

   (c) a frequency multiplier coupled to the mixer for receiving the intermediate frequency signal and multiplying the frequency of the signal by a predetermined multiplication factor to produce a frequency multiplied signal; and

   (d) means for producing an oscillator control signal based on the frequency multiplied signal output from the frequency multiplier, wherein the regulated oscillators module produces the intermediate frequency signal based on the oscillator control signal.

2. The quadrature phase modulation receiver of claim 1 wherein the means for producing an oscillator control signal comprises:

   (a) a phase shifter coupled to the frequency multiplier for receiving the frequency multiplied signal and shifting the phase of the

frequency multiplied signal by a predetermined amount to produce an output signal;

(b) a comparison signal formation circuit for receiving the intermediate frequency signal output from the regulated oscillators module and for producing an output signal having a predetermined relationship with the intermediate frequency signal; and

(c) a frequency and phase discriminator for receiving the output signals from the phase shifter and the comparison signal formation circuit and for producing the oscillator control signal based on the output signals from the phase shifter and the comparison signal formation circuit.

3. The quadrature phase modulation receiver of claim 1 wherein the received signal is a quadrature phase modulated signal and the frequency multiplier is a 4x frequency multiplier.

4. The quadrature phase modulation receiver of claim 3 wherein the 4x frequency multiplier comprises:

(a) a first power multiplier for squaring the intermediate frequency signal output from the mixer to produce a squared signal;

(b) a first DC blocking capacitor for removing DC offset components from the squared signal;

(c) a second multiplier for squaring the squared signal to produce a third output signal having a frequency that is four times the frequency of the intermediate frequency signal; and

(d) a second DC blocking capacitor coupled to the second power multiplier for removing DC components from the third output signal to produce the frequency multiplied signal.

5. The quadrature phase modulation receiver of claim 1 wherein the regulated oscillators module comprises:

(a) a heterodyne signal oscillator for producing the heterodyne signal;

(b) a voltage controlled oscillator (VCO) for producing an output signal having a predetermined relationship with the intermediate frequency; and

(c) a frequency synthesizer for receiving the output signal from the VCO and for producing the intermediate frequency signal.

6. The quadrature phase modulation receiver of claim 5 wherein the voltage controlled oscillator is adapted to receive the oscillator control signal and produce the output signal based on the oscillator control signal.

7. The quadrature phase modulation receiver of claim 2 wherein the comparison signal formation circuit comprises first and second squaring circuits and a multiplier circuit connected in series for

receiving and processing the intermediate frequency signal output from the regulated oscillators module.

8. The quadrature phase modulation receiver of claim 7 wherein:

(a) the first squaring circuit comprises first voltage multiplier having first and second inputs connected to each other and having a first output;

(b) the second squaring circuit comprises a second voltage multiplier having third and fourth inputs connected to each other and to the first output and having a second output; and

(c) the multiplier circuit comprises a three-input multiplier having a first input coupled to the first output, a second input coupled to the second output, and a third input coupled to the phase shifter.

9. The quadrature phase modulation receiver of claim 1 comprising:

(a) a phase discriminator for receiving the signal output from the mixer and the intermediate frequency signal and producing a signal indicative of transmitted data and a spreading code; and

(b) a demodulator for receiving the signal output from the phase discriminator and removing the spreading code.

10. The quadrature phase modulation receiver of claim 9 wherein the demodulator comprises a frequency hopping spread spectrum demodulator.

11. The quadrature phase modulation receiver of claim 9 wherein the demodulator comprises a direct sequence spread spectrum demodulator.

12. A method for maintaining synchronization between a quadrature phase modulation spread spectrum transmitter and a quadrature phase modulation spread spectrum receiver, the method comprising:

at a quadrature phase modulation spread spectrum receiver:

(a) receiving a quadrature phase modulated spread spectrum signal;

(b) mixing the quadrature phase modulated spread spectrum signal with a heterodyne signal to produce an intermediate frequency signal;

(c) removing the influence of data changes in the quadrature phase modulated spread spectrum signal from the intermediate frequency signal to produce an oscillator control signal;

(d) generating a synchronization signal based on the oscillator control signal; and

(e) demodulating the quadrature phase modulated spread spectrum signal using the synchronization signal.

13. The method of claim 12 wherein reducing influence of data changes in the quadrature phase modulated spread spectrum signal from the intermediate frequency signal includes multiplying the frequency of the intermediate frequency signal by a predetermined multiplication factor.

14. The method of claim 13 wherein multiplying the frequency of the intermediate frequency signal by a predetermined multiplication factor includes multiplying the intermediate frequency signal by a factor of four to produce a frequency multiplied signal.

15. The method of claim 14 wherein producing the oscillator control signal includes:

(a) shifting the phase of the frequency multiplied signal by a predetermined amount to produce a phase-shifted signal; and

(b) producing the oscillator control signal based on the phase-shifted signal.

16. The method of claim 15 wherein generating a synchronization signal comprises generating a signal having a frequency equal to the intermediate frequency based on the oscillator control signal.

17. The method of claim 14 wherein multiplying the frequency of the intermediate frequency signal by a factor of four includes:

(a) squaring the intermediate frequency signal to produce a squared signal;

(b) filtering out constant components from the squared signal;

(c) squaring the squared signal to produce a signal having a frequency equal to four times the intermediate frequency; and

(d) filtering out constant components from the signal having the frequency equal to four times the intermediate frequency.

18. The method of claim 12 wherein demodulating the quadrature phase modulated spread spectrum signal includes outputting the signal to a frequency hopping spread spectrum demodulator.

19. The method of claim 12 wherein demodulating the quadrature phase modulated spread spectrum signal includes outputting the signal to a direct sequence spread spectrum demodulator.

20. A computer program product comprising computer-executable instructions embodied in a computer-readable medium for performing steps comprising:

(a) receiving a quadrature phase modulated spread spectrum signal;

(b) mixing the quadrature phase modulated spread spectrum signal with a heterodyne signal to produce an intermediate frequency signal;

(c) removing the influence of data changes in the quadrature phase modulated spread spectrum signal from the intermediate frequency signal to produce an oscillator control signal;

(d) generating a synchronization signal based on the oscillator control signal; and

(e) demodulating the quadrature phase modulated spread spectrum signal using the synchronization signal.

21. The computer program product of claim 20 wherein reducing influence of data changes in the quadrature phase modulated spread spectrum signal from the intermediate frequency signal includes multiplying the frequency of the intermediate frequency signal by a predetermined multiplication factor.

22. The computer program product of claim 21 wherein multiplying the frequency of the intermediate frequency signal by a predetermined multiplication factor includes multiplying the intermediate frequency signal by a factor of four to produce a frequency multiplied signal.

23. The computer program product of claim 22 wherein producing the oscillator control signal includes:

(a) shifting the phase of the frequency multiplied signal by a predetermined amount to produce a phase-shifted signal; and

(b) producing the oscillator control signal based on the phase-shifted signal.

24. The computer program product of claim 23 wherein generating a synchronization signal comprises generating a signal having a frequency equal to the intermediate frequency based on the oscillator control signal.

25. The computer program product of claim 22 wherein multiplying the frequency of the intermediate frequency signal by a factor of four includes:

(a) squaring the intermediate frequency signal to produce a squared signal;

(b) filtering out constant components from the squared signal;

(c) squaring the squared signal to produce a signal having a frequency equal to four times the intermediate frequency; and

(d) filtering out constant components from the signal having a frequency equal to four times the intermediate frequency.

26. The computer program product of claim 20 wherein demodulating the quadrature phase modulated spread spectrum signal includes outputting the signal to a frequency hopping spread spectrum demodulator.

27. The computer program product of claim 20 wherein demodulating the quadrature phase modulated spread spectrum signal includes outputting the signal to a direct sequence spread spectrum demodulator.

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